Il Quaternario
3, n. 1, 1990, 61-72

A STREAM-FLOW CONTROLLED "WET" LATE QUATERNARY ALLUVIAL FAN, NW PELOPONNESE, GREECE

N. Kontopoulos - L. Stamatopoulos
Department of Geology, University of Patras, Patras, Greece

ABSTRACT - *A stream-flow controlled "wet" Late Quaternary alluvial fan, NW Peloponnese, Greece* - Il Quaternario, **3**, n. 1, 1990, pp. 61-72 -The Selemnos Fan is one of a series of similar Holocene alluvial fans between Panahaikon Mountain and the Gulf of Patras, developed in a wet Mediterranean climate. Three major lithofacies are distinguished: conglomerate, pebbly mudstone and sandy silt to mud. Sheet-like conglomerates may form in a manner analogous to crevasse splays. Channel-filling conglomerates are deposited on longitudinal bars. Pebbly mudstone is deposited from debris flows. The mud and silty sand are an overbank facies. Channel-filling conglomerate is the dominant facies, particularly in proximal parts of the fan. The Selemnos Fan differs from previously described "wet" alluvial fans, particularly in the absence of sandy facies. Similar fans of Pliocene-Quaternary age are common in Greece and may be characteristic of areas of Mediterranean climate.

RIASSUNTO - *Su un conoide ("wet fan") tardo Quaternario nel Peloponneso nord-occidentale, Grecia* - Il Quaternario, **3**, n. 1, 1990, pp. 61-72 - Il conoide di Selemnos fa parte di una serie di conoidi simili di età olocenica che si trovano fra il M. Panahaikon e il golfo di Patras che si sono formati in un ambiente climatico umido di tipo mediterraneo. Si possono distinguere tre tipi litologici principali: conglomerato, *mudstone* con ciottoli e limi sabbiosi fino a *mudstone.* Si possono formare conglomerati stratiformi in maniera analoga alle lingue di materiali accumulati da crevasse. Conglomerati di riempimento di canali sono depositati lungo fasce longitudinali e *mudstone* con ciottoli viene depositato dai *debris flow.* Peliti e sabbie limose sono in facies overbank. Particolarmente nelle parti prossimali del conoide la facies dominante è quella dei conglomerati di riempimento di canali. Il conoide di Selemnos differisce dai conoidi ("wet-fan") già descritti in particolar modo per l'assenza di facies sabbiose. Conoidi simili di età pliocenico-quaternaria sono comuni in Grecia e possono essere considerati caratteristici di aree a clima mediterraneo.

Key-words: Wet fan, sedimentology, Peloponnese
Parole chiave: Conoidi, sedimentologia, Peloponneso

1. INTRODUCTION

"Wet" alluvial fans, as defined by Schumm (1977) are widespread along the margins of many young mountain chains (Ori, 1982) and have been widely recognised in the geological record (e.g., Davis, 1974; Heward, 1978; Seni, 1980; Vos, 1975). There is, however, a disproportionate emphasis in studies of both modern and ancient fans on the fans of arid and semi-arid regions, compared with those in humid regions. Furthermore, there is much variability in the facies described from modern "wet" fans. Most well-studied "wet" alluvial fans are in proglacial outwash settings (Cherven, 1984; Boothroyd and Ashley, 1975; Boothroyd and Nummedal, 1978) and have braided channel patterns. Ori (1982) suggested a braided to meandering pattern for wet alluvial fan deposits in northern Italy, similar to the model 4 (high sinuosity gravelly rivers of Miall, 1985).

The purpose of this paper is to describe the characteristics of sediments from a Holocene "wet" alluvial fan deposited by the Selemnos river on the northern flank of Panahaikon mountain in western Greece. Depositional facies are related to modern alluvial fan processes and are compared to published descriptions of "wet" alluvial fans.

2. GEOLOGICAL SETTING

The Selemnos River is about 5.5 km long and drains the northern flank of Panahaikon Mountain, northeast of the city of Patras (Fig. 1). Its watershed is 11 km^2; the upper part consists principally of almost bare Cretaceous limestones of the Alpine basement; the lower part of Neogene shales, sandstones and conglomerates with scrub vegetation and olive groves. The lowermost 2.5 km of the river divide into two the channels which cross a gravelly alluvial fan, on which is built the village of Rion. Gradients range from 4° on the upper fan gradually decreasing to 2° on the distal fan. The fan forms a cuspate coastal promontory where it is prograding into the Gulf of Patras, which is there less than 100 m deep. The Selemnos fan is one of a series of similar fans between Panahaikon Mountain and the Gulf of Patras.

Average annual precipitation in Patras is 729 mm. Precipitation on Panahaikon Mountain is perhaps double this amount, and between November and March is generally in the form of snow. River flow is ephemeral, being generally restricted to the months of October to April, during which 88% of the precipitation is recorded.

In the Mediterranean region during the early and mid Holocene, a warm wet climate led to higher precipitation than today and widespread forest cover (Fairbridge, 1972). In the late Holocene (since 6.5 ka BP), the climate was drier and more seasonal, leading to accelerated sedimentation in stream valleys (Vita Finzi, 1969a, b). However, in Roman times (1.8÷2.1 ka BP) there was a cooler and wetter period (Fairbridge, 1972; Vita Finzi, 1964). At this time, however, Pausanius recorded that the river was perennial and its watershed was covered by a dense coniferous forest (Karambela, 1972). Similar wetter periods occured between 1000 and 1200 A.D. and 1430 and 1850 A.D. (Lamb, 1966; Vita Finzi, 1963).

The deeper internal structure of the fan is known from hydrogeological drilling (Monopolis, 1967; Kantas, 1978; Andronopoulos and Rojos, 1987). Drill records are insufficiently detailed for detailed sedimentological analysis, but do provide a basis for stratigraphy. The fan deposits consist of 10-20 m of conglomerate in the apical area. An east-west fault scarp in the Neogene basement separates this area from midfan, where conglomerates are up to 30 m thick and overlie older Pleistocene deposits (Fig. 1). A similar thickness of conglomerate is found over marine muds on the lower fan. The basal 20 m is a coarsening up sand to conglomerate sequence (probably a deltaic deposit), capped by coastal plant debris and a further 10 m of conglomerate (probably terrestrial). Boreholes near the lateral margins of the fan show some muddy sand interbedded with the conglomerates.

Although the age of the base of the fan body is unknown, the grading of the fan to modern sea level indicates that the upper part is of late Holocene age. Since in the late Pleistocene the Gulf of Patras was a lake basin at about 100 m below sea level, it is likely that any older Pleistocene fan deposits were eroded and the 30 m thickness is a sedimentary response to the late Pleistocene - Holocene rise in sea level. On the similar Milichos fan, 4 km to the southwest, a Roman bridge (dating between 146 BC and 285 AD) is now buried 3 m

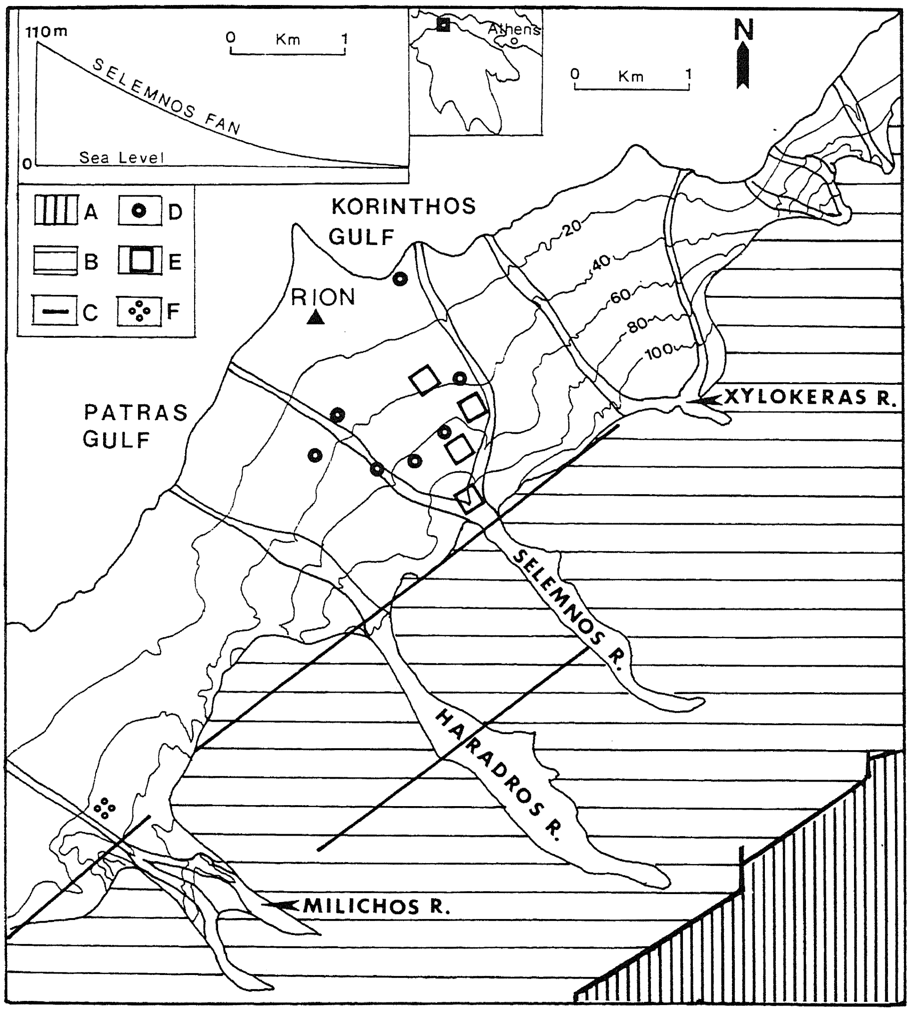

Fig. 1 - Geological map of the Selemnos watersheds. Insets show the location of study area in western Greece; and the longitudinal profile of the Selemnos Fan. A - Alpine basement rocks; B - Neogene sediments; C - fault; D - borehole; E - localities illustrated in photographs; F - Roman bridge

Cartina geologica degli spartiacque del Selemnos. Gli inserti mostrano la posizione geografica dell'area studiata nella Grecia occidentale; e il profilo longitudinale del conoide Selemnos. A - Rocce del basamento alpino; B - Sedimenti neogenici; C - Faglia; D - Sondaggio; E - Località illustrate nelle fotografie; F - Ponte romano

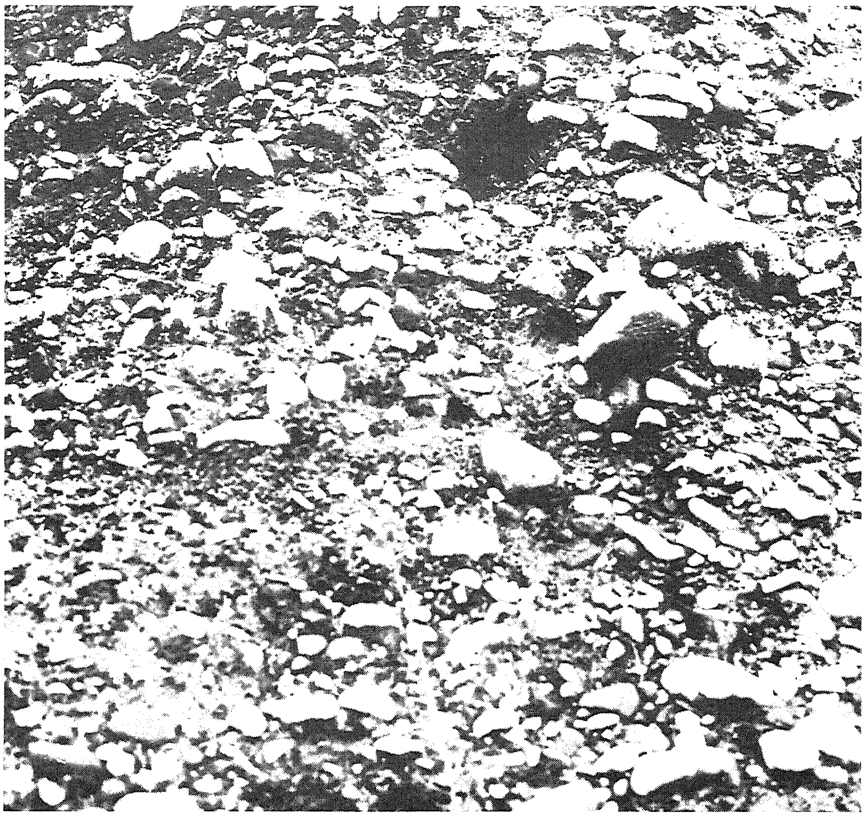

Fig. 2 - Facies A2 conglomerate showing rapid lateral variability in grain size
Conglomerato di facies A2: E' evidente la rapida variabilità laterale di granulometria

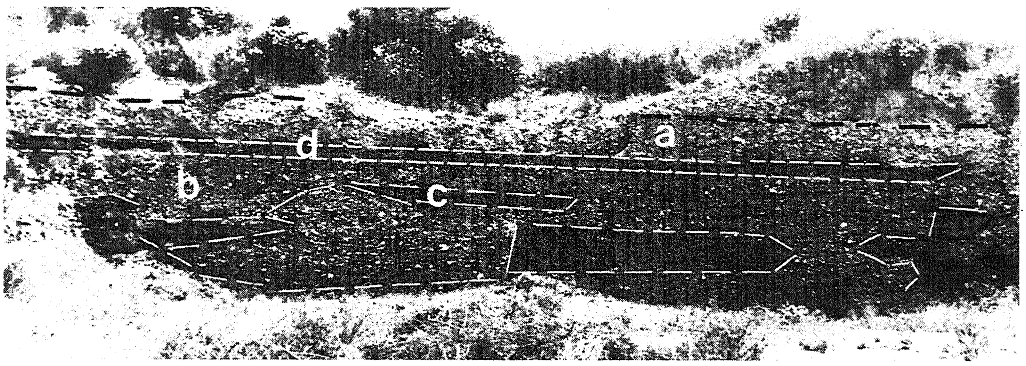

Fig. 3 - Fan cross section on midfan showing: (a) laterally persistent conglomerate unit with nearly flat and parallel boundary surfaces; (b) lenticular, channel-filling conglomerates; (c) isolated thin mud bed, probably representing low-stage deposition in a channel; (d) laterally persistent muds representing overbank deposits
Sezione trasversale del conoide a mezza altezza che mostra: (a) unità conglomeratica persistente lateralmente con superfici delimitanti all'incirca piane e parallele; (b) conglomerato di riempimento di canale a forma lenticolare; (c) isolato straterello di "pelite" che rappresenta probabilmente uno stadio di deposizione tardiva in un canale; (d) presenze laterali di "pelite" indicanti depositi di "overbank"

below the fan surface, demonstrating that fan aggradation has occured in the late Holocene (Fig. 1).

Several areas of western Greece have experienced considerable Pleistocene coastal uplift: both east and west of Patras, raised mid-Pleistocene marine and fan terraces are found (Kelletat et al., 1978; Keraudren and Sorel, 1987). At the same time, there has been rapid subsidence in other areas (Ferentinos et al., 1985). Although one low raised marine terrace is recognised in the Selemnos basin.

Settlements and agriculture make it difficult to map the surface facies distribution on the fan. However, sections of the fan sediments up to 7 m thick occur in natural river banks, road cuts and in excavations associated with the construction of the University of Patras. Sections are mostly from the mid fan, and are oriented both parallel and transverse to paleoflow. In the field, sections were logged and photographed, and the orientation of long axes of pebbles were measured. The matrix content and the texture of finer sediments was determined in the laboratory by standard sieve and pipette techniques (Carver, 1971).

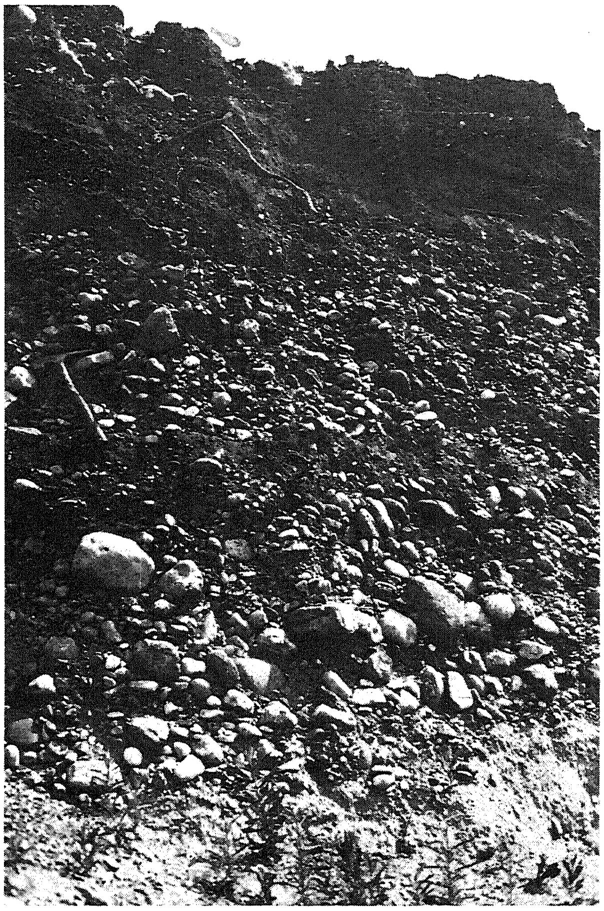

Fig. 4 - Conglomerate-filled channel showing overall indistinct coarse tail normal grading. Facies A2
Canale riempito di conglomerato che mostra una gradatura normale indistinta e grossolana all'estremità. Facies A2

3. SEDIMENTARY FACIES

The predominant lithology on the fan is conglomerate, both sheet-like (facies A1) and channeled (facies A2). On the midfan, lesser amounts of pebbly mudstone (facies B) and mud and silty sand (facies C) are found. Description of each facies is followed by discussion of inferred conditions of sedimentation.

A : Conglomerate

Description

The conglomerates are poorly sorted, mainly framework supported, with a mean grain size in the pebble to cobble range and a matrix (10%) of granules and coarse sand, corresponding to facies Gm of Miall (1985). Generally, the largest clasts have a-axes of 50 cm and b-axes of 35 cm. About 70% of the clasts are of limestone, 20% chert and 10% sandstone. All the conglomerates have poorly developed horizontal stratification, either with an indistinct coarse-tail normal grading or an irregular alternation of coarse- and fine-grained clasts. These coarser and finer layers are laterally discontinuous, commonly on a scale of less than a metre (Fig. 2).

Fig. 5 - Reversely graded conglomerate overlying sandy mud: outcrops to either side show that this conglomerate fills a channel. Facies A2
Conglomerato a gradatura inversa sovrastante una pelite sabbiosa: degli affioramenti su entrambi i lati indicano che questo conglomerato riempie un canale. Facies A2

Two facies are distinguished on the basis of bed geometry:

- facies A1: laterally persistent thin beds with nearly flat bounding surfaces (Fig. 3). Although generally indistinctly graded, a few beds show reverse grading. This facies does not occur on the proximal fan, and makes up only about 10% of the section on the mid fan. This facies is generally interbedded with mud and silty sand.

- facies A2: lenticular conglomerate beds typically 3 m thick and 30 m wide, with an erosional channelled base. The conglomerate fill generally shows poorly developed normal grading (Fig. 4) and fingers out laterally into structureless muddy sandstone of facies C. A few beds show reverse grading and a matrix supported character (Fig. 5). Some channel fill includes isolated, impersistent, thin mud beds (up to 50 cm thick) (Fig. 3). Locally, where the conglomerates directly overlie facies C, the channels are narrow with steep and in places overhanging walls (Fig. 6), and thin conglomerate beds (similar in character to facies A1) extend overbank to tens of metres beyond the channel. Some channels show stepped margins, reflecting several cut and fill events: the corresponding deposits show an alternation of coarser and finer beds (Fig. 7). The channelled conglomerates of this facies make up about 55% of the deposits on the mid fan.

On the proximal fan, channelled conglomerates make up almost the entire section. Normal grading is more pronounced and a few large clasts (a<1.5 m, b<1.0 m) are found on the floors of the channels (Fig. 8).

Pebble orientation was investigated by measurement of long axis orientations. Most clasts are oriented transverse to the paleocurrent directions inferred from the regional gradient and are imbricated up-flow (Fig. 9). The low directional variance of the clast fabric may be attributed to high-stage floods, when gravel transport shows minimum deflection from the downslope direction. Such conditions compare closely with the waning phase of the highest floods recorded from modern stream channels, particularly braided channels (Daeglas, 1962; Williams, 1971; Turner, 1983).

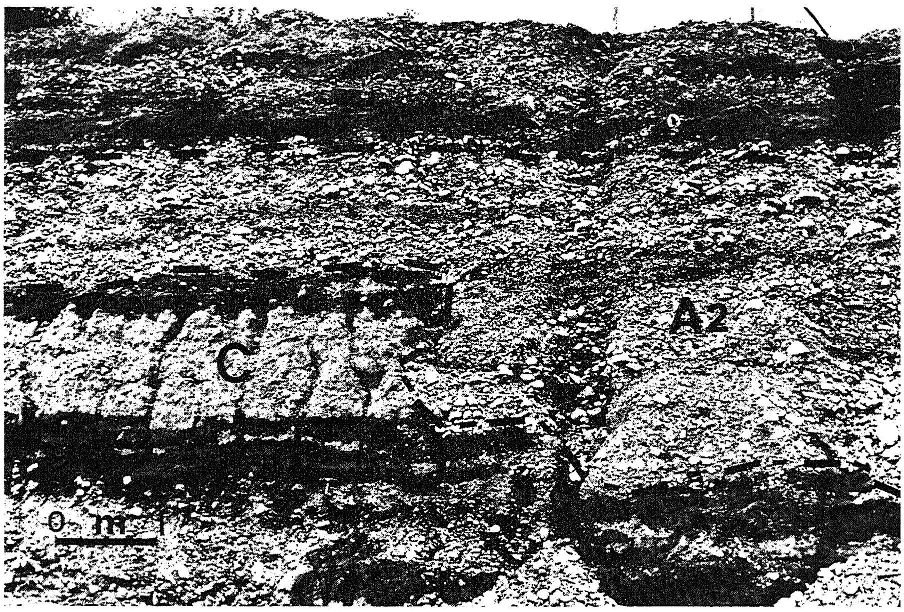

Fig. 6 - Steep-walled channel of facies A2 cut into facies C. Opposite channel wall is 5 m to right of phorograph
Canale a pareti ripide della facies A2 entro la facies C. Il fianco opposto dle canale si trova 5 m a destra della fotografia

Interpretation

The dominance of framework conglomerates is characteristic of braided streams (Rust, 1978a). The absence of epsilon cross-bedding in the gravel suggests the absence of point-bar deposits (Ricci Lucchi et al., 1981; Ori, 1982). Furthermore, the coarseness, poor sorting and structure of the conglomerate facies suggest high water discharge and relatively high sediment concentration in the flows (Steel and Thompson, 1983). The indistinct normal grading probably reflects deposition during waning discharge. The laterally irregular alternation of layers of coarser and finer grained clasts reflects lateral migration of the braid bars (Smith, 1974). The very low proportion of sand and granule matrix suggests simultaneous accumulation of clasts and matrix (Walker, 1975). Furthermore, this matrix does not possess sufficient strength to support the coarse clasts, and thus reflects low-viscosity flow processes. The support mechanism is therefore a combination of clast dispersion and normal stream-flood transport (Lewis, Laird and Powell, 1980).

Conglomerates of facies A1 are sheet deposits. The absence of cross stratification or marked wedging out of conglomerate bodies suggests that the sheets had little topographic relief. This facies is probably of similar genesis to the "laterally continuous stream flood

Fig. 7 - Conglomerates of facies A2 from the midfan showing alternating thin horizontal layers of coarser and finer conglomerate, with low angle scour and fill
Conglomerati di facies A2 nella parte mediana del conoide con alternanza di sottili strati orizzontali di conglomerati a grana più grossa e più fina mostranti una struttura a piccolo angolo di scavo e riempimento

Fig. 8 - Channel-filling conglomerate overlying and overlain by sandy mud. Note channel margin at left of photograph. Coarse clasts are concentrated near the base of the channel
Conglomerato di riempimento di canale tra due strati di pelite sabbiosa. Da notare il margine del canale a sinistra della fotografia. I clasti grossolani sono concentrati vicino alla base del canale

facies" of Mack and Rasmussen (1984), which they interpreted as forming where channels widened and shoaled to merge with the midfan surface. This facies commonly overlies overbank deposits, indicating that it may form in a manner analogous to crevasse splays. If so, the reverse grading in some beds may result from the progressive enlargement of the crevasse.

Conglomerates of facies A2 are typical of braided fluvial deposits (Allen, 1965; Eynon and Walker, 1974) that have accumulated in longitudinal bars in low-sinuosity multi-channel streams (Miall, 1977; Rust 1978a, b). The thin mud beds represent low-stage deposits. Reverse grading can be produced by rapidly rising floods (Allen, 1981). The rare matrix-supported conglomerates are probably debris flow deposits.

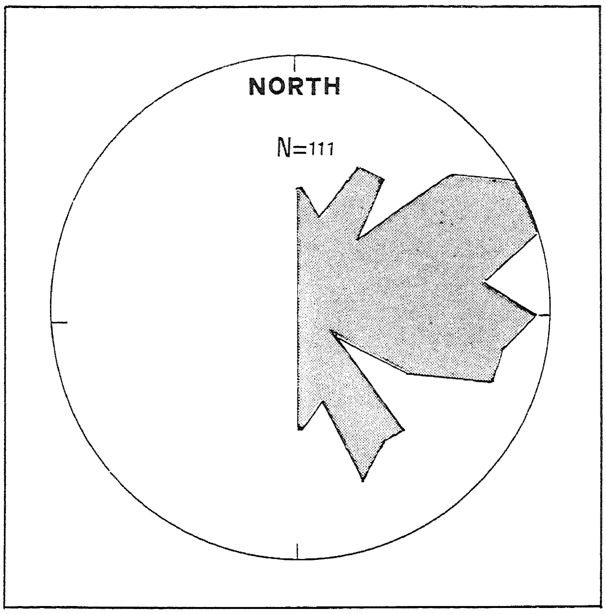

Fig. 9 - Rose diagram of a-axis pebble orientations from facies A2 on the midfan. Total count = 111; circle radius 10%. Most pebbles show imbrication to the SSE
Diagramma a rosetta dell'orientazione dell'asse a dei ciottoli della facies A2 nella parte mediana del conoide. Totale dei punti = 111; raggio del cerchio 10%. La maggior parte dei ciottoli mostrano una struttura imbricata verso SSE

B: Pebbly mudstone

Description

This facies consists of poorly sorted disorganised pebbly mudstones corresponding to facies Gms of Miall (1985) (Fig. 10), forming sheet-like deposits, typically 50 cm thick, than can be traced laterally for several metres. The mudstones contain about 2% clasts, of similar size to those in facies A, that are randomly distributed through the beds, with no apparent preferred orientation, grading or internal stratification. This facies makes up about 5% of the midfan area, and is interbedded with facies A or C.

Interpretation

This facies is similar to mudflow deposits described by Bull (1972). The random orientation of clasts may reflect either a short travel distance or high viscosity and strength in the continuous phase of the debris flow, which inhibited settling of clasts after the flow came to rest (Lewis et al., 1980).

C : Mud, and silty sand

Description

This facies occurs in units typically 3m thick, consisting of interbedded mud, silt, and silty sand in beds centimetres to decimetres thick with some very fine sand beds. The facies corresponds to Fl of Miall, 1985). These lithologies occasionally occur in coarsening upward sequences up to one metre thick (Fig. 11). Caliche and other pedogenic features are not present. Internal stratification is not seen within individual beds. This facies makes up about 30% of the midfan, where it is interbedded with facies A and B.

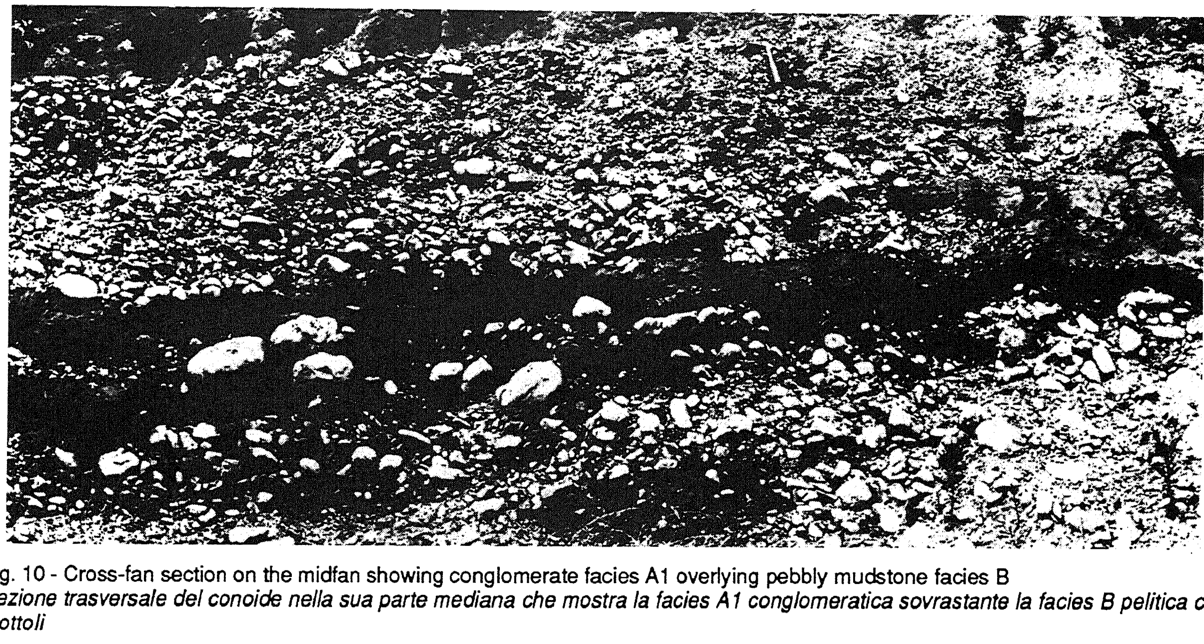

Fig. 10 - Cross-fan section on the midfan showing conglomerate facies A1 overlying pebbly mudstone facies B
Sezione trasversale del conoide nella sua parte mediana che mostra la facies A1 conglomeratica sovrastante la facies B pelitica con ciottoli

Interpretation

This facies is interpreted as accumulating on larger and more stable intrachannel bars during waning flood stages, in a manner analogous to overbank deposits. The rare coarsening-up sequences are probably due to reworking of the deposits by subsequent floods. The lack of stratification is probably the result of bioturbation by root growth. The lack of caliche and pedogenic features, despite the abundance of detrital carbonate, indicates either relatively high rainfall (perhaps seasonal) (Turner, 1983; Rust, 1984), or limited evaporation due to dense vegetation cover.

Fig. 11 - Radial section on the midfan showing overbank facies C overlying lenticular conglomerate facies A2
Sezione radiale nella parte mediana del conoide mostrante la facies C di "overbank" ricoprente una lente di conglomerato di facies A2

4. DISCUSSION

The historical evidence reviewed in the introduction suggests that the Selemnos watershed in classical times was well forested, and the river was perennial. There is no direct evidence for whether the vegetation cover on the gravelly fan was substantially different from the scrub cover present today. Compared with the modern watershed, a forested watershed would give steadier river discharge, more groundwater recharge, and more stable slopes, inhibiting the occurence of flash floods and muflows (Blackwelder, 1982; Hook, 1967). The observed sediment facies are consistent with such a model, with water laid sediments predominating. The cut and fill structures and red-brown colour of the sediments suggest fluctuations in discharge and groundwater level (Rust, 1984), consistent with a Mediterranean climate with wet winters and dry summers. The lack of caliche nodules and other pedogenic features such as rhoizoconcretions suggests high rainfall (which could be seasonal) (Turner, 1983; Rust, 1984).

Inferred facies distribution is illustrated in Figure 12. Water laid conglomerates predominate over the entire fan surface. Small areas of the fan, remote from the active channels, accumulate overbank sandy muds. The boreholes suggest that there is little stratigraphic variability, with conglomerates predominating on all segments of the terrestrial fan.

On the upper fan, cut and fill is most abundant, and deposition of gravel takes place principally on longitudinal bars. Similar processes predominate on the mid fan, but the preservation potential of overbank facies and rare mudflow deposits is higher, because reworking is less. From our limited data, we infer that the same channel processes predominate on the lower fan. Braided channel patterns persist throughout the fan.

Such a facies distribution differs from that described from other humid region fans. The persistance of braided channel facies right across the fan, in contrast to meandering patterns found on some fan (Ori, 1982) is a consequence of the high gradient of the fan, resulting from Late Pleistocene tectonic uplift of the source area and subsidence of the Gulf of Patras. Facies C on the Selemnos fan is more abundant than the corresponding facies Fl in proglacial outwash (model 2 of Miall, 1985), whereas the cross-stratified gravelly facies Gp is absent. Pebbly mudstone facies B is minor in abundance on the Selemnos Fan compared with Cherven's (1984) humid fan model, and his siltstone-filled channels are not present. Bedded sandy facies corresponding to facies SB of Miall (1985) is also absent on the Selemnos fan: the reason for this is unclear, but might be related to a predominance of conglomerates and shales in the source area. Alternatively, it may be related to reworking of any sand deposits by high discharges that occur every winter. The small watershed may promote large fluctuations in discharge.

Alluvial fan sediments of Pliocene and early Quaternary age elsewhere in Greece show similar facies distribution to that inferred for the Selemnos Fan. Channelled conglomerates of facies A2 are described as generally predominant in fans from the late Pliocene and early Pleistocene of Lakonia (Panagos et al., 1976, Piper et al., 1976), with pebbly mudstone abundant only in arid periods. On the flanks of Mount Olympos (Psilovikos, 1981), fans that formed under wet periglacial conditions include conglomerate, pebbly mudstone and sandy mud (similar to facies A, B and C of the Selemnos), but sandy facies are again absent.

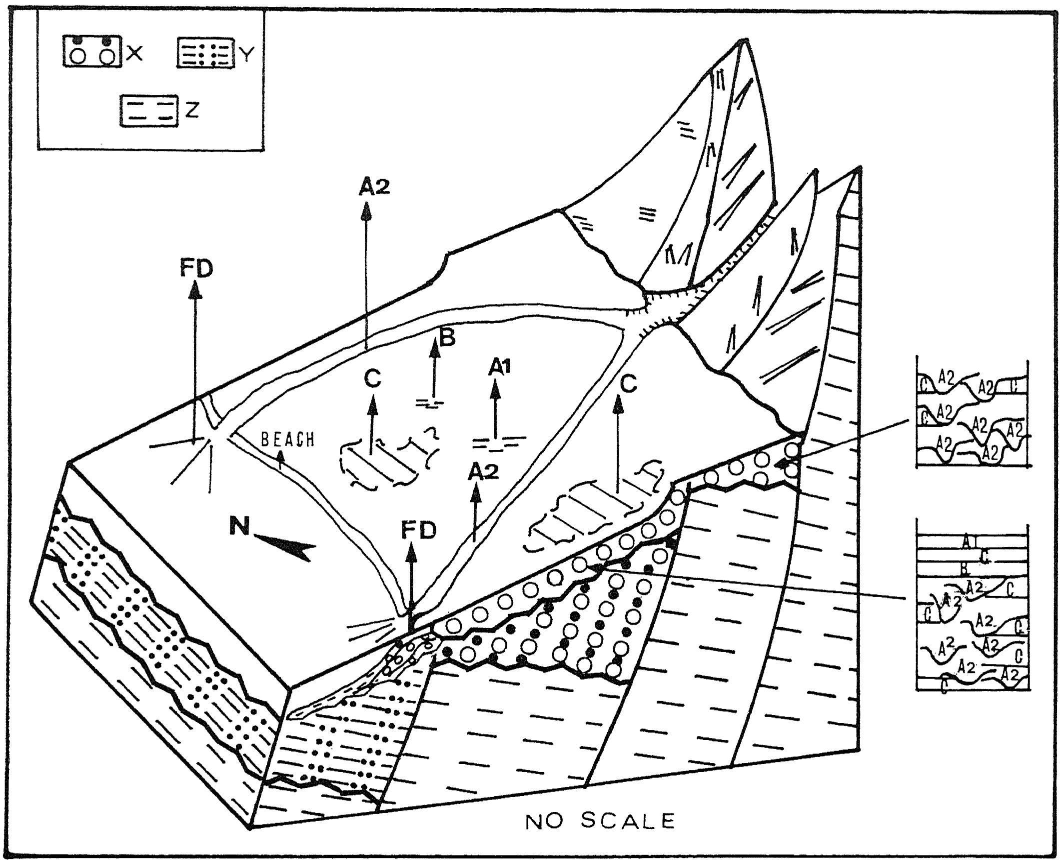

Fig. 12 - Depositional model for the Selemnos fan sediments. A1, A2, B, C are facies described in text; FD = sandy fan delta; X = early Pleistocene conglomerate and sand; Y = early Pleistocene silty mud; Z = Pliocene sediments
Modello deposizionale per i sedimenti del conoide Selemnos. A1, A2, B, C sono facies descritte nel testo; F, D = conoide sabbioso di delta; X = conglomerati e sabbie del Pleistocene inferiore; Y = "fango" limoso del Pleistocene inferiore; Z = sedimenti pliocenici

The distribution of facies on the Selemnos fan thus appears to be a good model for older fans developed in small drainage basins in a Mediterranean climate. Model 2 of Miall (1985) appears more typical of arctic climates and his Model 4, together with the model of Cherven (1984) may be more typical of large humid fans with a more even distribution of precipitation.

5. CONCLUSIONS

1. The Selemnos fan is a small alluvial fan developed in a Mediterranean climate. River flow is restricted to the winter at present, but may have been perennial a few thousand years ago prior to deforestation.
2. The predominant facies is channelled conglomerate (A2): sheet-like conglomerate (A1) and pebbly mudstone (B) are rare. Overbank sandy silt and mud is common, particularly at the margins of the fan. Bedded sand facies are absent, as are caliche and other pedogenetic features.
3. The Selemnos fan resembles Pliocene and early Quaternary alluvial fans found elsewhere in Greece. The particular facies distribution may be common in areas of Mediterranean climate.

ACKNOWLEDGMENTS

The authors thank D.J.W. Piper, and L. Brancaccio for their constructive review of the manuscript.

REFERENCES

Andronopoulos B. & Rojos D. (1987) - *Geotechnical investigation of Rio and Antirio coasts.* Technical report, Rio-Antirio Bridge Project.

Allen J.R.L. (1965) - *A review of the origin and characteristics of Recent alluvial sediments.* Sedimentology, **5**, 89-191.

Allen P.A. (1981) - *Sediments and processes on a small stream-flow dominated, Devonian alluvial fan, Shetland Islands.* Sediment. Geol., **29**, 31-66.

Blackwelder E. (1928) - *Mudflow as a geological agent in semi-arid mountains.* Bull. geol. Soc. Am., **39**, 465-484.

Boothroyd J.C. & Ashley G.M. (1975) - *Processes, bar morphology and sedimentary structures on braided outwash fans, northeastern Gulf of Alaska, in Jopling.* A.V. & McDonald, B.C. (editors), *Glaciofluvial and glaciolacustrine sedimentation.* Soc. Econ. Paleont. Mineral., Spec. Publ., **23**, 193-222.

Boothroyd J.C. & Nummedal D. (1978) - *Proglacial braided outwash: a model for humid alluvial-fan deposits, in Miall.* A.D. (editor), Fluvial Sedimentology, Canadian Soc. of Petroleum Geologists, Mem., **5**, 641-668.

Bull W.B. (1972) - *Recognition of alluvial fan deposits in the stratigraphic record.* In: J.K. Rigby and W.K. Hamblin (Editors), *Recognition of ancient sedimentary environments.* Soc. Econ. Palentol. Mineral., Spec. Publ., **16**, 63-83.

Carver R.E. (197) - Procedures in sedimentary petrology, Wiley N.Y., New York, 653 pp.

Cherven V.B. (1984) - *Early Pleistocene glacial outwash deposits in the eastern San Joaquin Valley, California: a model for humid-region alluvial fans.* Sedimentology, **31**, 823-836.

Davis J.F. (1974) - *The Newcastle coal measures, models of sedimentation and sedimentary history.* Unpublished Ph.D. thesis, University of Sydney.

Doeglas D.J. (1962) - *The structure of sedimentary deposits of braided rivers.* Sedimentology, **1**, 167-190.

Eynon G. & Walker R.G. (1974) - *Facies relationships in Pleistocene outwash gravels, Ontario: a model for bar growth in braided rivers.* Sedimentology, **21**, 43-70.

Fairbridge R. (1972) - *Quaternary sedimentation in the Mediterranean region controlled by tectonics, paleoclimates and sea level.* In D.J. Stanley (Editor), *The Mediterranean Sea: a natural sedimentation laboratory.* Dowden, Hutchinson & Ross, 99-113.

Ferentinos G., Brooks M. & Doutsos T. (1985) - *Quaternary tectonics in the Gulf of Patras, western Greece.* J. Struct. Geol., **7**, 713-717.

Heward A.P. (1978) - *Alluvial fan and lacustrine sediments from the Stephanian A and B (La Magdalena, Cinera-Matallaya and Sabero) coalfields, northern Spain.* Sedimentology, **25**, 451-488.

Hook R.L.B. (1967) - *Processes on arid-region alluvial fans.* J. Geol., **75**, 438-460.

Kantas K. (1978) - *Works of Bridging Rio-Antirion: Geology and Technical problems.* In: C.L. Goudas (Editor), *Bridging Rio-Antirion.* Univ. of Patras, Greece, 35-51.

Karambelas P.G. (1972) - *Prehistoric Olenos* [in Greek]. Patras, 150 p.

Kelletat D., Kowalczyk G., Schrödel B. & Winter K.P. (1978) - *Neotectonics in the Peloponnesian coastal regions.* In H. Cloos (Editor), *Alps, Appenines, Hellenides.* Stuttgart, 512-518.

Keraudren B. & Sorel, D. (1987) - *The terraces of Corinth (Greece) - a detailed record of eustatic sea level variations during the last 500,000 years.* Marine Geology, **77**, 99-107.

Lamb H.H. (1966) - *The changing climate.* London.

Lewis D.W., Laird M.G. & Powell R.D.(1980) - *Debris flow deposits of early Miocene age, Deadman Stream, Marlborough, New Zealand.* Sediment. Geol., **27**, 83-118.

Mack G.H. & Rasmussen K.A. (1984) - *Alluvial-fan sedimentation of the Gutler Formation (Permo-Pennsylvanian) near Gateway, Colorado.* Geol. Soc. Am. Bull., **95**, 109-116.

Miall A.D.(1977) - *A review of the braided river depositional environment.* Earth-Sci. Rev., **13**, 1-62.

Miall A.D. (1985) - *Architectural-Element Analysis: A new method of facies analysis applied to fluvial deposits.* Earth-Sci. Rev., **22**, 261-308.

Monopolis D.(1967) - *Geotechnical reconnaisance study of the areas proposed for the development of the Patras University Campus.* I.G.M.E., Technical report, No T433.

Ori G.G. (1982) - *Braided to meandering channel patterns in humid-region alluvial fan deposits, River Reno, Po Plain (northern Italy).* Sediment. Geol., **31**, 231-248.

Panagos A.G., Pe G.G. & Kontopoulos N. (1976) - *Analysis of the sediments of Afissos (Sparta).* Bull. Geol. Soc. Greece, **12**, 3-28 [in Greek].

Piper D.J.W., Panagos A.G., Kontopoulos N. & Pe G.G. (1976) - *Depositional environments of Pliocene littoral sediments, Gythion, southern Peloponnese, Greece.* Zt. dt. Geol. Ges. **127**, 435-444.

Psilovikos A.(1981) - *Geomorphological, morphogenetic, tectonic, sedimentological and climatic processes which led to the formation and evolution of alluvial fans of Olympos Mountain, Greece.* Pragmatia Ifigesias, Thessaloniki University, Greece, 158 p.

Ricci-Lucci F., Colella A., Ori G.G. & Ogliani F. (1981) - *Pliocene fan deltas of the Intra-Apenninic Basin, Bologna.* Int. Assoc. Sediment. Excursion Guide book, Second European Regional Meeting.

Rust. B.R. (1978a) - *A classification of alluvial channel systems.* In: A.D. Miall (Editor), *Fluvial Sedimentology.* Can. Soc. Petrol. Geol. Mem. **5**, 187-198.

Rust B.R. (1978b) - *Depositional models for braided alluvium.* In: A.D. Miall (Editor), *Fluvial Sedimentology.* Can. Soc. Petrol. Geol. Mem. **5**, 605-625.

Rust B.P. (1984) - *Proximal braidplain deposits in the Middle Devonian Malbaie Formation of eastern Gaspe, Quebec, Canada.* Sedimentology, **31**, 675-695.

Schumm S.A.(1977) - *The fluvial system.* Wiley, New York, 338 p.

Seni S.I. (1980) - *Sand-body geometry and depositional systems, Ogallala Formation, Texas.* Texas Bur. Econ. Geol., Univ. Texas, Austin, Rept. Invest. n. 105.

Smith N.D. (1974) - *Sedimentology and bar formation in the upper Kicking Horse River, a braided outwash stream.* Journal of Geology, **82**, 205-223.

Steel R.J. & Thomson D.B.(1983) - *Structure and textures in Trassic braided stream conglomerates (Bunter Pebble Beds) in the Sherwood Sandstone Group, North Staffordshire, England.* Sedimentology, **30**, 341-367.

Turner B.P.(1983) - *Braidplain deposits in the Upper Triassic Molteno Formation in the main Karroo (Gondwana) Basin, South Africa.* Sedimentology, **30**, 77-89.

Vita Finzi C. (1963) - *Carbon-14 dating of medieval alluvium in Libya.* Nature, **198**, 880.

Vita Finzi C. (1964) - *Synchronous stream deposition throughout the Mediterranean area in historical times.* Nature, **202**, 1324.

Vita Finzi C. (1969a) - *The Mediterranean Valleys.* Cambridge University Press, Cambridge. 131 p.

Vita Finzi C. (1969b) - *Late Quaternary continental deposits of central and western Turkey.* Man, **4**, 60-619.

Vos R.G. (1975) - *An alluvial plain and lacustrine model for the Precambrian Witwatersrand deposits of South Africa.* J. sedim. Petrol., **45**, 480-493.

Walker R.G. (1975) - *Conglomerate: sedimentary structures and facies models.* In: J.C. Harms, J.B. Southard, D.R. Spearing and R.G. Walker (Editors), *Depositional environments as interpreted from primary sedimentary structures and stratification sequences.* Soc. Econ. Paleontologists and Mineralogists, Short Course Notes, **2**, 133-161.

Williams G.E.(1971) - *Flood deposits of the sand-bed ephemeral streams of central Australia.* Sedimentology, **17**, 1-40.

Accettato per la stampa il 3.5.1990